

NVCS Results Discussion from Improvements #1

Summary

- For NVC Division, the project team recommends starting from scratch to efficiently design one auto-key that encompasses all relevant Divisions.
 - There are 59 Divisions in lower 48 + Alaska, of which 13 are Arctic, Neotropical, or marine aquatic making the total 46 Divisions in L48+AK.
 - This should not be very difficult or time consuming but it will take some work from experts.
 - Marion Reid comment: Is this a recommendation to do one auto-key for all lower 48 divisions + one for AK and one for HI? Or to do a couple or maybe even 3 auto-keys for lower 48, splitting the divisions into meaningful geographies?
- The potential agreement increase from rolling-up to NVC Macrogroup from Ecological System is variable—sometimes more than 20% and often over 10% for a specific system, but sometimes it is negligible or zero. In many cases, for major types (many plots, lots of acres mapped) the increase could be called substantial—often more than 10 percentage points. That suggests that final map accuracy will be higher if NVC Macrogroups are the direct mapping legend rather than Ecological Systems. Remember, however, that Macrogroups are broad regional concepts, and may lack the thematic resolution necessary for some applications.
- There are 158 Macrogroups in the lower 48 and Alaska; another 26 Macrogroups in Hawai'i. These numbers includes Macrogroups currently defined in the NVC for Ruderal vegetation. This is compared to some 760 ecological systems in lower 48 and Alaska, and another 32 systems in Hawai'i. These numbers for systems do not include any Ruderal or non-natural vegetation types, but do include all wetland/riparian and sparsely vegetated systems.
- For Auto-keys in GeoAreas where the relationship between Ecological System and NVC Group is complex, significant changes may be needed to the auto-key to produce Group attributions. Many of the details are captured in the individual GeoArea sections below.
- Relationships between Group and Ecological System vary across GeoAreas
 - 1, 4, 7E, 7W and HI: All relationships are clean
 - 2E: 75% of relationships are clean
 - 2W: 83% of relationships are clean
 - 3: 90% of relationships are clean
 - 5: 92% of relationships are clean
 - 6: 91% of relationships are clean
 - 8: 94% of relationships are clean
 - A small number of Ecological Systems have not yet been related to NVC
 - Overall, more than 9 of 10 relationships between NVC Group and Ecological System are simple and clean.
 - The complexity of the relationship when not simple varies—there is no general pattern. Each will have to dealt with on an individual basis, but the fundamental information is in this report and the GeoArea reports.
 - Need to define what we mean by “clean”, and verify these numbers before a final plan is created and time requirements are estimated.
- Groups can generally be ‘comfortably’ rolled-up to Macrogroups, and auto-keys for Macrogroup should match expert attributions more often.
- Floristic overlaps or differences between Ecological Systems and Groups will need to explored and accounted for.

- There is a trade-off between thematic resolution (Ecological System-Group-Macrogroup-Division) and agreement between expert and auto-keyed assignments, which likely transfers to the mapping process as well (higher agreement with lower thematic resolution). We must understand the impacts of that decision before any particular level of vegetation mapping is eliminated or added in the future, including how downstream production processes may need to be altered.
- The “gain” from mapping Group classes in particular, and Macrogroup to some extent, appear to be variable across types and geographies. By “gain”, we mean improved agreement between auto-key and expert, and potential improvement of final map accuracy.

Individual Geo Area NVC Results

- Cut and pasted from individual reports
- “Boiler plate” removed for the most part

GeoArea 1

US-NVC Groups

Within this GeoArea, some 167 terrestrial ecological system types could occur. Of these, 7 ecological system concepts have a practical 1:1 relationship with NVC Group concepts, and 157 of the remaining ecological system concepts nest cleanly within 42 NVC Group concepts. Three ecological systems had not been assigned an NVC Group. Those include South-Central Interior Small Stream and Riparian (CES202.706), South-Central Interior/ Upper Coastal Plain Wet Flatwoods (CES203.480), and South-Central Interior / Upper Coastal Plain Flatwoods (CES203.479). There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the auto-key would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing auto-keys. Within this GeoArea, no ecological system types have a more complex relationship with NVC Group concepts.

In GeoArea1 the ecological systems concepts are finely tessellated, making the relationship to the newly defined NVC Groups straightforward, avoiding the many to many relationships that would occur with more generalized ecological systems. The trade off however is the difficulty in classifying plots to the numerous types with the limited information available through most of the existing datasets. For other parts of the country the ecological systems to Group crosswalks are more complex, making an analysis of the improvement in the auto-key process at the Group level less relevant, therefore we do not include that summary here.

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE auto-keys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and auto-keys found at the ecological systems level. To evaluate the potential effect of using the auto-key for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-auto-key contingency table (Results Workbook), and also compared the percent of expert to auto-key matches at the ecological system level versus the Macrogroup level (Table 1).

There are 13 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 1 suggest rolling up to Macrogroup would yield improved results, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include diverse ecological system types. For example, three very broad Macrogroups together encompass 19 ecological systems and a large proportion of the natural upland forest acreage of GeoArea 1. These are:

- M007 Longleaf Pine & Sand Pine Woodland
- M008 Southern Mixed Deciduous-Evergreen Broadleaf Forest
- M016 Southern Hardwood & Pine Forest

Since these Macrogroups are broad regional units, they do not allow for many of the advantages of accurate ecological system assignments. At the scale of a regional mapping effort, distinguishing amongst the ecological systems is a desirable outcome; oftentimes outweighing the disadvantage of less accurate mapping results. More investment in field data collection, meeting minimum criteria of complete species composition, structural data, and environmental parameters would provide improved results in the auto-key. These field data then also lead to a better understanding of floristic and biogeographic patterns overall for individual systems which can then be incorporated into the sequence tables.

Auto-key results to Macrogroup and use in mapping would leave a lot of unanswered questions about the auto-keyed forest vegetation, but might be more appropriate for more extensive mapping efforts, or where the desired outcome does not require more detailed understanding of vegetation patterns in a landscape.

Some examples of how generalizing up from the ecological system to Macrogroup level would improve the agreement between the auto-key and expert assignments include:

For the upland longleaf pine types, rolling up to the Macrogroup level with the current auto-key assignments would increase the assignment agreement by 13%. This change would mean the primary diagnostics for assigning the plots would be the dominance of longleaf pine, the upland environment or indicators. The need to understand the biogeographic context would be reduced. At the Macrogroup level, it would still be important to distinguish between the Longleaf Pine & Sand Pine Woodland (M007), Wet Longleaf Pine & Southern Flatwoods (M161), as well as planted or ruderal pine types.

Generalizing the classification to the Loblolly & Shortleaf Pine – Oak Forest & Woodland Macrogroup would improve the agreement from the current auto-key assignments by 16% by removing the need to distinguish between West Gulf Coastal Plain Sandhill Oak and Shortleaf Pine Forest and Woodland (CES203.056) and West Gulf Coastal Plain Pine-Hardwood Forest (CES203.378). In order for the disagreement at the Macrogroup level to be reduced further, it would require refinement of the keys relative to ruderal, unclassified and planted forest classes.

Southern Mixed Deciduous – Evergreen Broadleaf Forest (M008) improves slightly over the component ecological systems agreement.

Agreement in the Southern Coastal Plain Evergreen Hardwood & Conifer Swamp (M032) increases only slightly over the member ecological systems. Real improvement in the assignment will require making the distinction between the concepts underlying the seepage swamps and baygall systems, specifically

the Atlantic Coastal Plain Streamhead Seepage, Swamp, Pocosin and Baygall (CES203.372; M032) and the Atlantic Coastal Plain Peatland Pocosin and Canebrake (CES203.267; M065) clearer.

Table 1. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M007 Longleaf Pine & Sand Pine Woodland	7	293	68%	81%
M008 Southern Mixed Deciduous-Evergreen Broadleaf Forest	6	152	14%	26%
M157 Loblolly & Shortleaf Pine - Oak Forest & Woodland	2	77	62%	78%
M016 Southern Hardwood & Pine Forest	6	130	45%	48%
M153 Central Mesophytic Hardwood Forest	3	75	13%	16%
M032 Southern Coastal Plain Evergreen Hardwood & Conifer Swamp	3	106	32%	38%
M033 Southern Coastal Plain Basin Swamp	2	57	9%	9%
M161 Wet Longleaf Pine & Southern Flatwoods	2	41	46%	46%
M309 Southeastern Coastal Plain Patch Prairie [Placeholder]	1	2	50%	50%
M057 Eastern North American Coastal Grassland & Shrubland	1	1	0%	0%
M065 Atlantic & Gulf Coastal Plain Bog & Fen	1	1	0%	0%
M067 Atlantic & Gulf Coastal Plain Pondshore & Wet Meadow	1	2	0%	0%
M079 Eastern North American Atlantic Salt Marsh	1	12	0%	42%

GeoArea 2E

US-NVC Groups

Within this GeoArea, some 68 terrestrial ecological system types could occur. Of these, 26 have a practical 1:1 relationship with NVC Group concepts, and 25 nest cleanly within 15 NVC Group concepts (1:many group:system relationship), for a total of 51 or 75% of ecological system concepts with a clean relationship to an NVC Group. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the autokey would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. Within this GeoArea, 16 (24%) ecological system types have a more complex relationship with NVC Group concepts (**Error! Reference source not found.**). A review of these more complex ecological system to NVC Group relationships indicates that, while revisions to the autokey would be necessary to use the NVC Groups for plot assignments the changes required for GeoArea 2E do not appear to be prohibitively substantive and would likely improve the plot classification process in this GeoArea. The simplification of the geographic modifiers from the riparian types would help to clear up some confusion in the classification of these types that often share many species. The addition of a riparian forest Group would help to differentiate two rather distinct habitats that have been previously been combined (i.e. shrubland and forest). The splitting of the Northern Rocky Mountain Avalanche Chute Shrubland into a more general high elevation shrubland Group and a riparian Group should help to make the classification of this type less difficult and error prone. Similarly

the change from the North Pacific Avalanche Chute Shrubland to a more general Vancouverian Alder - Salmonberry - Willow Shrubland Group should be an improvement as accurate classification of the Avalanche Chute Shrubland systems typically required expert photo review and the changes made moving to the NVC Group should reduce the need for this time intensive review. Splitting the Northern Rocky Mountain Mesic Montane Mixed Conifer Forest into two NVC Groups one that recognizes the unique Western Red-cedar - Western Hemlock Forest is a welcome change that should be relatively easy to accomplish with minor revisions to the auto-key. The inability to distinguish these biologically important forest types from the more common mesic grand-fir forests is a common criticism of the current land cover maps for the region. Breaking the Rocky Mountain Alpine-Montane Wet Meadow into two Groups distinguished by elevation also seems beneficial. Currently this system is used to map a very wide variety of wet alpine and montane habitats and more definition in these areas seems warranted.

One area of concern is the combination of many of the sagebrush systems into only two NVC-Groups. [Note: there are other sagebrush Groups for the dwarf-sages, such as black sage, low sage; and montane sagebrush steppe remains as a separate NVC Group]. While assigning sagebrush plots to systems is difficult and agreement between auto key and experts assignments was often low for these types, they represent complex habitats and caution should be used to avoid oversimplification in these types. While the geographic modifiers associated with the sagebrush systems can cause confusion, usually because it is difficult to decide where one type ends and the other begins, many reviewers of the land cover maps suggest that these projects require more detailed information on the sagebrush types than is currently provided. We should be careful to make sure the NVC-Groups provide an adequate level of definition for these diverse types.

Table 2. Ecological Systems of GeoArea 2E that have complex relationships with NVC Groups. Interrelated Systems and Groups are shown in the heavy-outline boxes. The number of NVC Groups each system is related to is shown in the Groups column, and the number of Ecological Systems each NVC Group is related to is shown in the Systems column.

Ecological System	NVC Group	Groups	Systems
Columbia Basin Foothill Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	1	5
Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Rocky Mountain Lower Montane-Foothill Riparian Woodland and	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5

Shrubland	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Columbia Basin Palouse Prairie	G273 Northern Rocky Mountain Lower Montane, Foothill & Valley Grassland	2	2
	G275 Northern Rocky Mountain Montane-Foothill Mesic Deciduous Shrubland	2	2
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	G273 Northern Rocky Mountain Lower Montane, Foothill & Valley Grassland	1	2
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	G272 Northern Rocky Mountain Montane-Foothill Dry Deciduous Shrubland	2	1
	G275 Northern Rocky Mountain Montane-Foothill Mesic Deciduous Shrubland	2	2
Columbia Plateau Steppe and Grassland	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	1	3
Great Basin Xeric Mixed Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	1	3
Inter-Mountain Basins Big Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Inter-Mountain Basins Big Sagebrush Steppe	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Northern Rocky Mountain Avalanche Chute Shrubland	G305 Northern Rocky Mountain High Montane Mesic Shrubland [Provisional]	2	3
	G504 Rocky Mountain & Great Basin Montane Alder & Birch Riparian Shrubland	2	1
Northern Rocky Mountain Subalpine Deciduous Shrubland	G305 Northern Rocky Mountain High Montane Mesic Shrubland [Provisional]	1	3
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	G217 Central Rocky Mountain Interior Western Red-cedar - Western Hemlock Forest	2	2
	G211 Central Rocky Mountain Mesic Grand Fir - Douglas-fir Forest	2	2
Rocky Mountain Alpine-Montane Wet Meadow	G521 Vancouverian & Rocky Mountain Montane Wet Meadow	2	2
	G520 Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland	2	1

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table in the Results Workbook, and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 1).

There are 14 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. Rolling up to the Macrogroup improves auto-key and expert agreement for six of these 14 Macrogroups when compared to agreement for the ecological system level. For five of these Macrogroups that show increased levels of agreement, improvement is by 20% or more.

While the results in Table 1 suggest rolling up to Macrogroup would yield a higher level of agreement, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example the Northern Rocky Mountain Montane & Foothill Grassland & Shrubland contains 7 ecological systems and encompasses most (in terms of map area) of the non-forest habitats in the mountainous portions of the GeoArea. These types range from very dry foothill grasslands to very mesic sub-alpine shrublands and combining them into one class would not be advantageous for many applications.

Table 3. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level.

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M093 Great Basin Saltbrush Scrub	1	18	83%	83%
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe	5	178	42%	79%
M170 Great Basin & Intermountain Dwarf Sage Shrubland & Steppe	2	64	59%	59%
M171 Great Basin & Intermountain Dry Shrubland & Grassland	1	50	14%	14%
M151 Northern Great Plains Woodland	1	36	0%	0%
M017 Northern Rocky Mountain Lower Montane & Foothill Forest	6	301	39%	83%
M020 Rocky Mountain Subalpine & High Montane Conifer Forest	8	347	49%	84%
M022 Southern Rocky Mountain Lower Montane Forest	1	6	0%	0%
M026 Intermountain Singleleaf Pinyon - Western Juniper Woodland	2	61	85%	85%
M034 Rocky Mountain & Great Basin Flooded & Swamp Forest	1	50	14%	50%
M099 Rocky Mountain Alpine Scrub, Forb Meadow & Grassland	3	60	73%	78%
M048 Northern Rocky Mountain Montane & Foothill Grassland & Shrubland	7	255	54%	77%
M168 Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow	1	98	28%	28%
M082 Cool Semi-Desert Alkali-Saline Wetland	1	8	88%	88%

GeoArea 2W

US-NVC Groups

Within this GeoArea, some 179 terrestrial ecological system types could occur. Of these, 57 have a practical 1:1 relationship with NVC Group concepts, and 91 nest cleanly within 45 NVC Group concepts (1:many group:system relationship), for a total of 148 or 83% of ecological system concepts with a clean relationship to an NVC Group. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There

is some limited potential that the floristic information found within the autokey would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. Within this GeoArea, 29 (16%) ecological system types have a more complex relationship with NVC Group concepts (**Error! Reference source not found.**). A review of these more complex ecological system to NVC Group relationships indicates that, while revisions to the autokey would be necessary to use the NVC Groups for plot assignments the changes required for GeoArea 2W do not appear to be prohibitively substantive and would likely improve the plot classification process in this GeoArea. The simplification of the geographic modifiers from the riparian types would help to clear up some confusion in the classification of these types that often share many species. The addition of a riparian forest Group would help to differentiate two rather distinct habitats that have been previously been combined (i.e. shrubland and forest). The splitting of the Northern Rocky Mountain Avalanche Chute Shrubland into a more general high elevation shrubland Group and a riparian Group should help to make the classification of this type less difficult and error prone. Similarly the change from the North Pacific Avalanche Chute Shrubland to a more general Vancouverian Alder - Salmonberry - Willow Shrubland Group should be an improvement as accurate classification of the Avalanche Chute Shrubland systems typically required expert photo review and the changes made moving to the NVC Group should reduce the need for this time intensive review. Splitting the Northern Rocky Mountain Mesic Montane Mixed Conifer Forest into two NVC Groups, with one that recognizes the unique Western Red-cedar - Western Hemlock Forest, is a welcome change that should be relatively easy to accomplish with minor revisions to the auto-key. The inability to distinguish these biologically important forest types from the more common mesic grand-fir forests is a common criticism of the current land cover maps for the region. Breaking the Rocky Mountain Alpine-Montane Wet Meadow into two Groups distinguished by elevation also seems beneficial. Currently this system is used to map a very wide variety of wet alpine and montane habitats and more definition in these areas seems warranted.

One area of concern is the combination of many of the sagebrush systems into only two NVC-Groups [Note: there are other sagebrush Groups for the dwarf-sages, such as black sage, low sage; and montane sagebrush steppe remains as a separate NVC Group]. While assigning sagebrush plots to systems is difficult and agreement between auto key and experts assignments was often low for these types, they represent complex habitats and caution should be used to avoid oversimplification in these types. While the geographic modifiers associated with the sagebrush systems can cause confusion, usually because it is difficult to decide where one type ends and the other begins, many reviewers of the land cover maps suggest that their projects require more detailed information on the sagebrush types than is currently provided. We should be careful to make sure the NVC-Groups provide an adequate level of definition for these diverse types.

Table 4. Ecological Systems of GeoArea 2W that have complex relationships with NVC Groups. Interrelated Systems and Groups are shown in the heavy-outline boxes. The number of NVC Groups each system is related to is shown in the Groups column, and the number of Ecological Systems each NVC Group is related to is shown in the Systems column.

Ecological System	NVC Group	Groups	Systems
Columbia Basin Foothill Riparian Woodland and Shrubland	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4

Ecological System	NVC Group	Groups	Systems
Columbia Basin Foothill Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	1	5
Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
Columbia Basin Palouse Prairie	G273 Northern Rocky Mountain Lower Montane, Foothill & Valley Grassland	2	2
Columbia Basin Palouse Prairie	G275 Northern Rocky Mountain Montane-Foothill Mesic Deciduous Shrubland	2	2
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	G273 Northern Rocky Mountain Lower Montane, Foothill & Valley Grassland	1	2
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	G275 Northern Rocky Mountain Montane-Foothill Mesic Deciduous Shrubland	2	2
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	G272 Northern Rocky Mountain Montane-Foothill Dry Deciduous Shrubland	2	1
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	G212 East Cascades Mesic Grand Fir - Douglas-fir Forest	2	1
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	G217 Central Rocky Mountain Interior Western Red-cedar - Western Hemlock Forest	2	2

Ecological System	NVC Group	Groups	Systems
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	G211 Central Rocky Mountain Mesic Grand Fir - Douglas-fir Forest	2	2
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	G217 Central Rocky Mountain Interior Western Red-cedar - Western Hemlock Forest	2	2
Northern Rocky Mountain Western Larch Savanna	G211 Central Rocky Mountain Mesic Grand Fir - Douglas-fir Forest	1	2
Columbia Plateau Steppe and Grassland	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	1	3
Great Basin Xeric Mixed Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	1	3
Inter-Mountain Basins Big Sagebrush Shrubland	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Inter-Mountain Basins Big Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
Inter-Mountain Basins Big Sagebrush Steppe	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Inter-Mountain Basins Big Sagebrush Steppe	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
North Pacific Alpine and Subalpine Dry Grassland	G354 Vancouverian Alder - Salmonberry - Willow Shrubland	1	4
North Pacific Avalanche Chute Shrubland	G305 Northern Rocky Mountain High Montane Mesic Shrubland [Provisional]	2	3
North Pacific Avalanche Chute Shrubland	G354 Vancouverian Alder - Salmonberry - Willow Shrubland	2	4
North Pacific Montane Grassland	G354 Vancouverian Alder - Salmonberry - Willow Shrubland	1	4
North Pacific Montane Shrubland	G354 Vancouverian Alder - Salmonberry - Willow Shrubland	1	4
Northern Rocky Mountain Avalanche Chute Shrubland	G305 Northern Rocky Mountain High Montane Mesic Shrubland [Provisional]	2	3
Northern Rocky Mountain Avalanche Chute Shrubland	G504 Rocky Mountain & Great Basin Montane Alder & Birch Riparian Shrubland	2	1
Northern Rocky Mountain Subalpine Deciduous Shrubland	G305 Northern Rocky Mountain High Montane Mesic Shrubland [Provisional]	1	3
North Pacific Hardwood-Conifer Swamp	G256 North Pacific Maritime Hardwood-Conifer Rich Swamp	2	3
North Pacific Hardwood-Conifer Swamp	G610 North Pacific Maritime Poor Swamp & Bog Forest	2	2
North Pacific Shrub Swamp	G256 North Pacific Maritime Hardwood-Conifer Rich Swamp	3	3
North Pacific Shrub Swamp	G322 Vancouverian Wet Shrubland	3	4

Ecological System	NVC Group	Groups	Systems
North Pacific Shrub Swamp	G610 North Pacific Maritime Poor Swamp & Bog Forest	3	2
North Pacific Intertidal Freshwater Wetland	G254 North Pacific Lowland Riparian Forest & Woodland	1	3
North Pacific Lowland Riparian Forest and Shrubland	G254 North Pacific Lowland Riparian Forest & Woodland	2	3
North Pacific Lowland Riparian Forest and Shrubland	G322 Vancouverian Wet Shrubland	2	4
North Pacific Montane Riparian Woodland and Shrubland	G322 Vancouverian Wet Shrubland	2	4
North Pacific Montane Riparian Woodland and Shrubland	G507 North Pacific Montane Riparian Woodland	2	1
Rocky Mountain Alpine-Montane Wet Meadow	G520 Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland	2	1
Rocky Mountain Alpine-Montane Wet Meadow	G521 Vancouverian & Rocky Mountain Montane Wet Meadow	2	2
Temperate Pacific Subalpine-Montane Wet Meadow	G521 Vancouverian & Rocky Mountain Montane Wet Meadow	1	2
North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-Field and Meadow	G317 North Pacific Alpine-Subalpine Dwarf-Shrubland & Heath	2	1
North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-Field and Meadow	G320 North Pacific Alpine-Subalpine Turf & Herbaceous Meadow	2	1

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table in the Results Workbook, and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 1).

There are 25 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. Rolling up to the Macrogroup improves auto-key and expert agreement for 17 of these 25 Macrogroups when compared to agreement for the ecological system level. For 8 of these Macrogroups that show increased levels of agreement, improvement is by 20% or more.

While the results in Table 1 suggest rolling up to Macrogroup would yield a higher level of agreement, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example the Northern Rocky Mountain Montane & Foothill Grassland & Shrubland contains 7 ecological systems and encompasses most (in terms of map

area) of the non-forest habitats in the mountainous portions of the GeoArea. These types range from very dry foothill grasslands to very mesic sub-alpine shrublands; combining them into one class would not be advantageous for many applications.

Table 5. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level.

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
Great Basin Saltbrush Scrub Macrogroup	2	78	82%	83%
Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup	5	249	41%	65%
Great Basin & Intermountain Dwarf Sage Shrubland & Steppe Macrogroup	3	150	77%	77%
Great Basin & Intermountain Dry Shrubland & Grassland Macrogroup	2	69	42%	54%
Quercus agrifolia - Quercus lobata - Umbellularia californica - Cupressus spp. - Pinus spp. Forest & Woodland Macrogroup	2	51	35%	35%
Quercus garryana - Quercus kelloggii - Pseudotsuga menziesii - Arbutus menziesii Forest & Woodland Macrogroup	5	198	54%	73%
Northern Rocky Mountain Lower Montane & Foothill Forest Macrogroup	9	326	48%	70%
Rocky Mountain Subalpine & High Montane Conifer Forest Macrogroup	8	348	53%	64%
Southern Rocky Mountain Lower Montane Forest Macrogroup	3	12	50%	100%
Calocedrus decurrens - Pinus (lambertiana, jeffreyi, monticola) - Abies concolor var. lowiana Forest Macrogroup	7	243	34%	70%
Tsuga heterophylla - Picea sitchensis - Sequoia sempervirens - Acer macrophyllum Forest Macrogroup	8	400	49%	80%
Abies magnifica - Abies X shastensis - Tsuga mertensiana - Pinus contorta var. murrayana Forest Macrogroup	6	262	60%	90%
Intermountain Singleleaf Pinyon - Western Juniper Woodland Macrogroup	6	132	85%	95%
Rocky Mountain Two-needle Pinyon - Juniper Woodland Macrogroup	1	14	100%	100%
Rocky Mountain & Great Basin Flooded & Swamp Forest Macrogroup	1	13	15%	92%
Vancouverian Flooded & Swamp Forest Macrogroup	2	80	33%	43%
Rocky Mountain Alpine Scrub, Forb Meadow & Grassland Macrogroup	4	33	48%	48%
Vancouverian Alpine Scrub, Forb Meadow & Grassland Macrogroup	1	50	88%	88%

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
Great Basin Saltbrush Scrub Macrogroup	2	78	82%	83%
Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup	5	249	41%	65%
Great Basin & Intermountain Dwarf Sage Shrubland & Steppe Macrogroup	3	150	77%	77%
Great Basin & Intermountain Dry Shrubland & Grassland Macrogroup	2	69	42%	54%
Quercus agrifolia - Quercus lobata - Umbellularia californica - Cupressus spp. - Pinus spp. Forest & Woodland Macrogroup	2	51	35%	35%
Quercus garryana - Quercus kelloggii - Pseudotsuga menziesii - Arbutus menziesii Forest & Woodland Macrogroup	5	198	54%	73%
Northern Rocky Mountain Lower Montane & Foothill Forest Macrogroup	9	326	48%	70%
Rocky Mountain Subalpine & High Montane Conifer Forest Macrogroup	8	348	53%	64%
Southern Rocky Mountain Lower Montane Forest Macrogroup	3	12	50%	100%
Calocedrus decurrens - Pinus (lambertiana, jeffreyi, monticola) - Abies concolor var. lowiana Forest Macrogroup	7	243	34%	70%
Tsuga heterophylla - Picea sitchensis - Sequoia sempervirens - Acer macrophyllum Forest Macrogroup	8	400	49%	80%
Abies magnifica - Abies X shastensis - Tsuga mertensiana - Pinus contorta var. murrayana Forest Macrogroup	6	262	60%	90%
Intermountain Singleleaf Pinyon - Western Juniper Woodland Macrogroup	6	132	85%	95%
Rocky Mountain Two-needle Pinyon - Juniper Woodland Macrogroup	1	14	100%	100%
Rocky Mountain & Great Basin Flooded & Swamp Forest Macrogroup	1	13	15%	92%
Northern Rocky Mountain Montane & Foothill Grassland & Shrubland Macrogroup	8	338	40%	72%
Southern Rocky Mountain Montane Grassland & Shrubland Macrogroup	2	9	33%	33%
Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow Macrogroup	2	55	29%	29%
Northern Vancouverian Lowland & Montane Grassland & Shrubland Macrogroup	2	56	41%	52%
Great Plains Shortgrass Prairie & Shrubland Macrogroup	1	3	0%	0%
Cool Interior Chaparral Macrogroup	2	21	67%	71%

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
Great Basin Saltbrush Scrub Macrogroup	2	78	82%	83%
Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup	5	249	41%	65%
Great Basin & Intermountain Dwarf Sage Shrubland & Steppe Macrogroup	3	150	77%	77%
Great Basin & Intermountain Dry Shrubland & Grassland Macrogroup	2	69	42%	54%
Quercus agrifolia - Quercus lobata - Umbellularia californica - Cupressus spp. - Pinus spp. Forest & Woodland Macrogroup	2	51	35%	35%
Quercus garryana - Quercus kelloggii - Pseudotsuga menziesii - Arbutus menziesii Forest & Woodland Macrogroup	5	198	54%	73%
Northern Rocky Mountain Lower Montane & Foothill Forest Macrogroup	9	326	48%	70%
Rocky Mountain Subalpine & High Montane Conifer Forest Macrogroup	8	348	53%	64%
Southern Rocky Mountain Lower Montane Forest Macrogroup	3	12	50%	100%
Calocedrus decurrens - Pinus (lambertiana, jeffreyi, monticola) - Abies concolor var. lowiana Forest Macrogroup	7	243	34%	70%
Tsuga heterophylla - Picea sitchensis - Sequoia sempervirens - Acer macrophyllum Forest Macrogroup	8	400	49%	80%
Abies magnifica - Abies X shastensis - Tsuga mertensiana - Pinus contorta var. murrayana Forest Macrogroup	6	262	60%	90%
Intermountain Singleleaf Pinyon - Western Juniper Woodland Macrogroup	6	132	85%	95%
Rocky Mountain Two-needle Pinyon - Juniper Woodland Macrogroup	1	14	100%	100%
Rocky Mountain & Great Basin Flooded & Swamp Forest Macrogroup	1	13	15%	92%
Cool Semi-Desert Alkali-Saline Wetland Macrogroup	1	50	80%	82%

GeoArea 3

US-NVC Groups

Within this GeoArea, some 117 terrestrial ecological system types could occur. Of these, 33 have a practical 1:1 relationship with NVC Group concepts, and 72 nest cleanly within 37 NVC Group concepts (1: many group : system relationship), for a total of 117 or 90% of ecological system concepts with a clean relationship to an NVC Group. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the autokey

would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. Within this GeoArea, 10 (9%) ecological system types have a more complex relationship with NVC Group concepts (**Error! Reference source not found.**). Here we provide additional commentary on the implications for autokey adjustment brought by these types.

- Dominance of life form, already incorporated into the auto-keys, can account for and key the differences between G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland and G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest
- Differentiating Steppe from Grassland is possible with the information on lifeform cover, which is incorporated into the auto-keys. These NVC Groups have further defined Ecological Systems along a moisture gradient, differentiating by detailed floristic composition in addition to relative life form cover will improve the key.
- Dominance by life form (woodland vs. shrubland), already incorporated into the auto-keys, and geographic location of each point, can account for and key the differences between G533 North American Warm Desert Riparian Low Bosque & Shrubland and G508 Sonoran-Chihuahuan Warm Desert Riparian Scrub.
- North Pacific Avalanche Chute Shrubland is a difficult system as it is more defined by the physical location than by species composition, as tree species can be maintained in a shrub-like form, and the species composition can be nearly identical to shrublands along riparian areas and in other wetland settings not associated with avalanche chutes. Slope, elevation and aspect, while extremely informative, are not adequate to confirm the landform characteristics of an avalanche chute. The distinction of 2 different NVC Groups defined more on geography and floristics will probably be straightforward to implement in the sequence table.
- North Pacific Shrub Swamp ecological system is very wide spread, such that several Groups now include the component associations. Geographic location information will be needed to key to each Group in turn.

Table 6. Ecological Systems of GeoArea 3 that have complex relationships with NVC Groups. Interrelated Systems and Groups are shown in the heavy-outline boxes. The number of NVC Groups each system is related to is shown in the Groups column, and the number of Ecological Systems to which each NVC Group related is shown in the Systems column.

Ecological System	NVC Group	Groups	Systems
Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Great Basin Xeric Mixed Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	1	3
Inter-Mountain Basins Big Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush	2	3

	Shrubland & Steppe		
Inter-Mountain Basins Big Sagebrush Steppe	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
North American Warm Desert Riparian Woodland and Shrubland	G533 North American Warm Desert Riparian Low Bosque & Shrubland	2	2
	G508 Sonoran-Chihuahuan Warm Desert Riparian Scrub	2	3
Sonoran Fan Palm Oasis	G508 Sonoran-Chihuahuan Warm Desert Riparian Scrub	1	3
North Pacific Avalanche Chute Shrubland	G305 Northern Rocky Mountain High Montane Mesic Shrubland [Provisional]	2	3
	G354 Vancouverian Alder - Salmonberry - Willow Shrubland	2	8
North Pacific Montane Grassland	G354 Vancouverian Alder - Salmonberry - Willow Shrubland	1	8
North Pacific Montane Riparian Woodland and Shrubland	G507 North Pacific Montane Riparian Woodland	2	1
	G322 Vancouverian Wet Shrubland	2	4
North Pacific Shrub Swamp	G256 North Pacific Maritime Hardwood-Conifer Rich Swamp	3	3
	G610 North Pacific Maritime Poor Swamp & Bog Forest	3	2
	G322 Vancouverian Wet Shrubland	3	4

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table, and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 7).

There are 23 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 7 suggest rolling up to Macrogroup would yield improved results, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example, in the case of Macrogroup 009 (*Quercus agrifolia* - *Quercus lobata* - *Umbellularia californica* - *Cupressus* spp. - *Pinus* spp. Forest & Woodland) rolling up from systems to the MG would improve agreement from 52% to 78%, a significant increase. However, this Macrogroup contains 7 diverse ecological systems, ranging from Central Valley oak woodlands and savannas to coastal pine woodlands, mixed conifer oak types in the foothills of the Sierras and Coast Ranges, and the mixed evergreen forests found just inland of the fog belt close to the

coast. Combining all of these into a single map class would result in the loss of much ecological information. A sequence table for this Macrogroup would not be difficult to construct, but investments would better be made in improving keying of the individual systems.

Macrogroup 025 (*Abies magnifica* - *Abies X shastensis* - *Tsuga mertensiana* - *Pinus contorta* var. *murrayana* Forest) is an interesting case, where rolling up from systems to Macrogroup improved agreement between expert and auto-key from 62% to 93% (Table 7). This suggests the Macrogroup concept is well understood, or can be clearly distinguished in individual plots, but the system types comprising the Macrogroup are somewhat difficult to separate in a sequence table. This Macrogroup includes the subalpine forests and woodlands of the Sierras (red fir, lodgepole, subalpine western juniper, mountain hemlock) which are often mixed conifer forests, with gradients of moisture and topographic position, along with fire history, determining species composition. Further work on clarifying the differences amongst these systems is needed.

Table 7. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M088 Mojave-Sonoran Semi-Desert Scrub	2	71	38%	39%
M089 Viscaino-Baja California Desert Scrub	1	6	0%	0%
M093 Great Basin Saltbrush Scrub	2	25	56%	56%
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe	4	137	80%	96%
M171 Great Basin & Intermountain Dry Shrubland & Grassland	1	1	0%	0%
M009 <i>Quercus agrifolia</i> - <i>Quercus lobata</i> - <i>Umbellularia californica</i> - <i>Cupressus</i> spp. - <i>Pinus</i> spp. Forest & Woodland	7	257	52%	78%
M019 <i>Quercus garryana</i> - <i>Quercus kelloggii</i> - <i>Pseudotsuga menziesii</i> - <i>Arbutus menziesii</i> Forest & Woodland	3	115	63%	68%
M020 Rocky Mountain Subalpine & High Montane Conifer Forest	2	40	63%	73%
M023 <i>Calocedrus decurrens</i> - <i>Pinus</i> (<i>lambertiana</i> , <i>jeffreyi</i> , <i>monticola</i>) - <i>Abies concolor</i> var. <i>lowiana</i> Forest	6	190	57%	71%
M024 <i>Tsuga heterophylla</i> - <i>Picea sitchensis</i> - <i>Sequoia sempervirens</i> - <i>Acer macrophyllum</i> Forest	3	53	96%	98%
M025 <i>Abies magnifica</i> - <i>Abies X shastensis</i> - <i>Tsuga mertensiana</i> - <i>Pinus contorta</i> var. <i>murrayana</i> Forest	4	175	62%	93%
M026 Intermountain Singleleaf Pinyon - Western Juniper Woodland	3	82	93%	98%
M036 Warm Mediterranean & Desert Riparian, Flooded & Swamp Forest	1	48	100%	100%
M101 Vancouverian Alpine Scrub, Forb Meadow & Grassland	3	30	57%	57%

M045 California Annual & Perennial Grassland	2	32	75%	81%
M043 California Chaparral	5	198	58%	92%
M044 California Coastal Scrub	1	50	90%	90%
M050 Southern Vancouverian Lowland Grassland & Shrubland	1	5	80%	80%
M168 Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow	1	12	92%	92%
M091 Warm Interior Chaparral	1	50	26%	26%
M094 Cool Interior Chaparral	2	75	40%	61%
M058 Cool Pacific Coastal Beach, Dune & Bluff Vegetation	1	50	92%	92%
M082 Cool Semi-Desert Alkali-Saline Wetland	1	8	100%	100%

GeoArea 4

US-NVC Groups

Within this GeoArea, some 117 terrestrial ecological system types could occur. Of these 112, or 96% of ecological system concepts have a practical 1:1 relationship with NVC Group concepts. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the autokey would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. Within this GeoArea, just 5 (4%) of ecological system types have a 1:2 or more complex relationship with NVC Group concepts. Here we provide additional commentary on the implications for autokey adjustment brought by these types.

Inter-Mountain Basins Big Sagebrush Steppe. This type relates to two NVC Group concepts, Intermountain Mesic Tall Sagebrush Shrubland & Steppe and Intermountain Dry Tall Sagebrush Shrubland. Adjustments to autokeys to capture these adjustments should be relatively easy, but require that plot data include more complete floristic information, which will form the primary indications that distinguish these two types. The ability to actually map and model these concepts as two distinct units could be quite challenging, at least within this GeoArea where these types are found within their drier, more southerly extreme of their range.

North American Warm Desert Riparian Woodland and Shrubland. This type relates to two NVC Group concepts, Sonoran-Chihuahuan Warm Desert Riparian Scrub and North American Warm Desert Riparian Low Bosque & Shrubland.

Rocky Mountain Alpine-Montane Wet Meadow. This type relates to two NVC Group concepts, Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland and Vancouverian & Rocky Mountain Montane Wet Meadow....

More complex relationships between ecological system concepts and NVC Group concepts are found within three types.

Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland and Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland. These types relate to two different NVC Group concepts, Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest and Rocky Mountain

& Great Basin Lowland & Foothill Riparian & Seep Shrubland. This classification split between treed and shrub-dominated components of riparian areas may be relatively easy to identify from plot data within the autokey, although they may or may not provide practical units for mapping, modeling, and analysis, since these components tend to represent distinct successional patches within the same riparian area.

US-NVC Macrogroups

This report section requires further development and interpretation; this is preliminary material.

There are approximately 26 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. The project contingency table for this GeoArea arranged ecological system types according to the US-NVC Macrogroup that would encompass their existing vegetation components. This facilitates rapid analysis to evaluate the potential effect of using the autokey for Macrogroups; i.e., there may be disagreements between expert and autokeys at the ecological systems level that would be resolved if the intention was to roll-up labeled classes to broader Macrogroup classes. The following types listed below are those for which this could be the case within this GeoArea.

Madrean Warm Lowland Evergreen Woodland Macrogroup (9 of 15 disagreements resolved)

Madrean Warm Montane Forest & Woodland Macrogroup (1 of 3)

Rocky Mountain Subalpine & High Montane Conifer Forest Macrogroup (37 of 52)

Southern Rocky Mountain Lower Montane Forest Macrogroup (46 of 80)

Intermountain Singleleaf Pinyon - Western Juniper Woodland Macrogroup (14 of 55)

Southern Rocky Mountain Montane Grassland & Shrubland Macrogroup (4 of 53)

Great Plains Shortgrass Prairie & Shrubland Macrogroup (6 of 17)

Warm Interior Chaparral Macrogroup (10 of 28)

Apacherian-Chihuahuan Semi-Desert Grassland & Steppe Macrogroup (23 of 40)

Chihuahuan Desert Scrub Macrogroup (31 of 71)

Mojave-Sonoran Semi-Desert Scrub Macrogroup (22 of 68)

Great Basin & Intermountain Dry Shrubland & Grassland Macrogroup (17 of 79)

Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup (17 of 100)

Great Basin Saltbrush Scrub Macrogroup (4 of 21)

Rocky Mountain Alpine Scrub, Forb Meadow & Grassland Macrogroup (6 of 9)

GeoArea 5

US-NVC Groups

Within this GeoArea, some 104 terrestrial ecological system types could occur. Of these, 43 have a practical 1:1 relationship with NVC Group concepts, and 53 nest cleanly within 34 NVC Group concepts (1: many group : system relationship), for a total of 96 or 92% of ecological system concepts with a clean relationship to an NVC Group. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the autokey would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. Within this GeoArea, 6 (6%) ecological system types have a more complex relationship with NVC Group concepts (**Error! Reference source not found.**). The number of system-Group inter-relationships is relatively small and the relationships are easily handled by the existing auto-keys or small alterations to them. Here we provide additional commentary on the implications for autokey adjustment brought by these types.

Table 8. Ecological Systems of GeoArea 5 that have complex relationships with NVC Groups. Interrelated Systems and Groups are shown in the heavy-outline boxes. The number of NVC Groups each system is related to is shown in the Groups column, and the number of Ecological Systems each NVC Group is related to is shown in the Systems column.

Ecological System	NVC Group	Groups	Systems
Inter-Mountain Basins Big Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Inter-Mountain Basins Big Sagebrush Steppe	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	G272 Northern Rocky Mountain Montane-Foothill Dry Deciduous Shrubland	2	1
	G275 Northern Rocky Mountain Montane-Foothill Mesic Deciduous Shrubland	2	2

Rocky Mountain Alpine-Montane Wet Meadow	G521 Vancouverian & Rocky Mountain Montane Wet Meadow	2	2
	G520 Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland	2	1

Inter-Mountain Basins Big Sagebrush Shrubland - This System is related to two Groups. Differentiating between these Groups, G303 Intermountain Dry Tall Sagebrush Shrubland and G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe, should be relatively easy to accomplish based on associated species differences (dry vs. mesic species). These species may need to be parsed out in the existing auto-keys or characteristic species may need to be added.

Intermountain Basins Big Sagebrush Steppe – As with the previous System, this System is related to two Groups. Differentiating between these Groups, G303 Intermountain Dry Tall Sagebrush Shrubland and G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe, should be relatively easy to accomplish based on associated species differences (dry vs. mesic species). These species may need to be parsed out in the existing auto-keys or characteristic species may need to be added.

Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland – This System is related to two Groups, G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland and G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest. It should be possible to differentiate between these two Groups based on lifeform (shrubland vs. forest), which is already in the auto-key.

Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland – As with the previous System, this System is related to two Groups, G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland and G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest. It should be possible to differentiate between these two Groups based on lifeform (shrubland vs. forest), which is already in the auto-key.

Northern Rocky Mountain Montane-Foothill Deciduous Shrubland – This System is related to two Groups, themselves related along a moisture gradient, G272 Northern Rocky Mountain Montane-Foothill Dry Deciduous Shrubland and G275 Northern Rocky Mountain Montane-Foothill Mesic Deciduous Shrubland. It should be possible to differentiate these Groups based on component species (dry vs. mesic).

Rocky Mountain Alpine-Montane Wet Meadow – This System is related to two Groups, G521 Vancouverian & Rocky Mountain Montane Wet Meadow and G520 Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland. These Groups are nominally distinguished by elevation though that may not always hold steady across the range of the Groups. It will have to be seen whether there are characteristic species that would reliably distinguish these two Groups.

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table, and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 1).

There are 24 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 1 suggest rolling up to Macrogroup would yield improved results, in some areas, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. Combining System results yields a small increase (<10%) in agreement for 20 of the 24 Macrogroups so the gain for these is likely not worth the loss in detail. Three of the remaining four Macrogroups that would see a significant gain are the among the most common in the dataset (and arguably on the landscape) however the loss in detail would be substantial. For example, rolling up the seven systems within M020 Rocky Mountain Subalpine & High Montane Conifer Forest would increase the agreement from 60% to 84%. However, this Macrogroup includes a wide variety of habitats from thin-soiled, harsh environments that support open lodgepole pine forests to aspen forests to mesic/wet-mesic spruce-fir forests. The reduction in ecological detail would be great and it would be wise to determine if sufficient gains in agreement could be made through revising the auto-keys, clearing up confusing classification concepts, and possibly using more thoroughly collected data to assign sites.

Table 9. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level.

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M093 Great Basin Saltbrush Scrub	2	12	83%	83%
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe	3	105	50%	98%
M171 Great Basin & Intermountain Dry Shrubland & Grassland	1	4	0%	0%
M012 Central Oak-Hardwood & Pine Forest	2	58	71%	78%
M014 Acer saccharum - Betula alleghaniensis - Pinus strobus - Tsuga canadensis Forest	1	4	100%	100%
M016 Southern Hardwood & Pine Forest	2	20	40%	40%
M151 Northern Great Plains Woodland	5	143	43%	52%
M153 Acer (barbatum, saccharum) - Tilia americana - Fagus grandifolia - (Liriodendron tulipifera) Forest	1	50	62%	62%
M017 Northern Rocky Mountain Lower Montane & Foothill Forest	6	160	69%	92%
M020 Rocky Mountain Subalpine & High Montane Conifer Forest	7	136	60%	84%
M022 Southern Rocky Mountain Lower Montane Forest	3	63	25%	25%
M026 Intermountain Singleleaf Pinyon - Western Juniper Woodland	1	8	100%	100%
M030 Northern & Central Swamp Forest	1	5	20%	20%
M037 Eastern & Central North American Boreal Conifer & Hardwood Forest	2	20	0%	0%
M116 Great Plains Cliff, Scree & Rock Vegetation	1	8	0%	0%

M048 Northern Rocky Mountain Montane & Foothill Grassland & Shrubland	3	34	18%	47%
M049 Southern Rocky Mountain Montane Grassland & Shrubland	1	6	67%	67%
M168 Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow	1	13	8%	8%
M051 Great Plains Mixedgrass Prairie & Shrubland	4	62	61%	71%
M052 Great Plains Sand Grassland & Shrubland	2	64	33%	39%
M053 Great Plains Shortgrass Prairie & Shrubland	1	29	93%	93%
M054 Great Plains Tallgrass Prairie, Savanna & Shrubland	2	5	80%	80%
M124 Northern & Central Alvar & Glade	2	7	0%	0%
M082 Cool Semi-Desert Alkali-Saline Wetland	1	28	29%	29%

GeoArea 6

US-NVC Groups

Within this GeoArea, some 135 terrestrial ecological system types could occur. Of these, 47 have a practical 1:1 relationship with NVC Group concepts, and 76 nest cleanly within 45 NVC Group concepts (1: many group : system relationship), for a total of 123 or 91% of ecological system concepts with a clean relationship to an NVC Group. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the auto-key would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing auto-keys. Within this GeoArea, 7 (5%) ecological system types have a more complex relationship with NVC Group concepts (**Error! Reference source not found.**). Here we provide additional commentary on the implications for auto-key adjustment brought by these types.

Table 10. Ecological Systems of GeoArea 6 that have complex relationships with NVC Groups. Interrelated Systems and Groups are shown in the heavy-outline boxes. The number of NVC Groups each system is related to is shown in the Groups column, and the number of Ecological Systems each NVC Group is related to is shown in the Systems column.

Ecological System	NVC Group	Groups	Systems
Inter-Mountain Basins Big Sagebrush Shrubland	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3
Inter-Mountain Basins Big Sagebrush Steppe	G303 Intermountain Dry Tall Sagebrush Shrubland	2	3
	G302 Intermountain Mesic Tall Sagebrush Shrubland & Steppe	2	3

Ecological System	NVC Group	Groups	Systems
North American Warm Desert Riparian Woodland and Shrubland	G533 North American Warm Desert Riparian Low Bosque & Shrubland	2	2
	G508 Sonoran-Chihuahuan Warm Desert Riparian Scrub	2	3
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	G508 Sonoran-Chihuahuan Warm Desert Riparian Scrub	1	3
North American Warm Desert Riparian Mesquite Bosque	G533 North American Warm Desert Riparian Low Bosque & Shrubland	1	2
Rocky Mountain Alpine-Montane Wet Meadow	G521 Vancouverian & Rocky Mountain Montane Wet Meadow	2	2
	G520 Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland	2	1
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland	G526 Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland	2	5
	G503 Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest	2	4

Inter-Mountain Basins Big Sagebrush Steppe and Inter-Mountain Basins Big Sagebrush Shrubland.

These two ecological system types each relate to two NVC Group concepts which themselves are related to other systems: Intermountain Mesic Tall Sagebrush Shrubland & Steppe Group and Intermountain Dry Tall Sagebrush Shrubland Group. Adjustments to auto-keys to capture these complications should be relatively easy, but require that plot data include more complete floristic information, which will form the primary indications that distinguish these two Groups. These are minor systems in this GeoArea. In fact, no samples were assessed with the auto-key or by experts so likely not an issue here.

North American Warm Desert Riparian Woodland and Shrubland. This type relates to parts of two NVC Group concepts which themselves are related to other systems: North American Warm Desert Riparian Low Bosque & Shrubland Group and Sonoran-Chihuahuan Warm Desert Riparian Scrub Group. The part of this system related to the North American Warm Desert Riparian Low Bosque & Shrubland Group is dominated by *Baccharis* spp., and *Fallugia paradoxa* growing along drainages. The part of this system related to the Sonoran-Chihuahuan Warm Desert Riparian Scrub Group is lower elevation (<1200 m) desert riparian sites that are dominated by *Acer negundo*, *Fraxinus velutina*, *Populus fremontii*, *Salix gooddingii*, *Salix lasiolepis*, *Celtis laevigata* var. *reticulata*, *Platanus racemosa*, or *Juglans major* growing in riparian areas.

North American Warm Desert Lower Montane Riparian Woodland and Shrubland. This type relates to part of the Sonoran-Chihuahuan Warm Desert Riparian Scrub Group, which is also related in part to North American Warm Desert Riparian Woodland and Shrubland system. The part of this system related to the Sonoran-Chihuahuan Warm Desert Riparian Scrub Group is higher elevation (1100 m) desert riparian sites that are dominated by *Populus angustifolia*, *Populus deltoides* ssp. *wislizeni*, *Populus fremontii*, *Platanus wrightii*, *Juglans major*, *Fraxinus velutina*, *Alnus oblongifolia*, or *Sapindus saponaria*. Other parts of this group relate to lower elevation North American Warm Desert Riparian Woodland and Shrubland, and Sonoran Fan Palm Oasis (does not occur in this GeoArea).

North American Warm Desert Riparian Mesquite Bosque. This type relates to part of the North American Warm Desert Riparian Low Bosque & Shrubland, which is also related in part to North American Warm Desert Riparian Woodland and Shrubland system. The part of this system related to North American Warm Desert Riparian Low Bosque & Shrubland Group is dominated by *Prosopis* spp growing along intermittently flooded drainages and riparian areas.

Rocky Mountain Alpine-Montane Wet Meadow. This type relates to two NVC Group concepts: Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland Group and Vancouverian & Rocky Mountain Montane Wet Meadow Group. The part of this system related to the Rocky Mountain Alpine-Montane Wet Meadow Group would occur in montane-subalpine elevation herbaceous wetlands in this GeoArea. The part of this system related to the Vancouverian & Rocky Mountain Subalpine Snowbed, Wet Meadow & Dwarf-Shrubland Group would include *Dasiphora fruticosa* ssp. *floribunda* Shrublands and other wet shrublands.

Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland. This type relates to two group concepts: Rocky Mountain & Great Basin Lowland & Foothill Riparian & Seep Shrubland and Rocky Mountain & Great Basin Lowland & Foothill Riparian Forest. This classification split between treed and shrub-dominated components of riparian areas may be relatively easy to identify from plot data within the auto-key, although they may or may not provide practical units for mapping, modeling, and analysis, since these components tend to represent distinct successional patches within the same riparian area.

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE auto-keys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and auto-keys found at the ecological systems level. To evaluate the potential effect of using the auto-key for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-auto-key contingency table, and also compared the percent of expert auto-key matches at the system level versus the Macrogroup level (Table 1).

There are 26 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 1 suggest rolling up to Macrogroup would yield improved results, especially Apacherian-Chihuahuan Semi-Desert Grassland & Steppe, Comanchian Forest & Woodland, and Rocky Mountain Two-needle Pinyon - Juniper Woodland, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example, the Comanchian Forest & Woodland Macrogroup clusters a set of 4 system types in GeoArea 6: Edwards Plateau Mesic Canyon, Edwards Plateau Dry-Mesic Slope Forest and Woodland, Edwards Plateau Limestone Savanna and Woodland, and Llano Uplift Acidic Forest, Woodland and Glade. So, while rolling up from system to Macrogroup may improve the number of matches between auto-key and expert, the roll-up would conceal important vegetation differences grouping mesic bottomland forests and dry upland woodlands, and is probably not desirable.

On the other hand, Rocky Mountain Two-needle Pinyon - Juniper Woodland Macrogroup is composed of two similar ecological systems in this GeoArea (Southern Rocky Mountain Juniper Woodland and Savanna and Southern Rocky Mountain Pinyon-Juniper Woodland) that could be grouped to significantly improve the number of auto-key to expert matches from 64% to 96%, because confusion was almost entirely between these two systems.

Another example, Apacherian-Chihuahuan Semi-Desert Grassland & Steppe Macrogroup (41 matches) is composed of 5 ecological systems (12%) that could be grouped to improve auto-key accuracy. However, in GeoArea 6, these systems are still poorly auto-keyed and are often confused with Western Great Plains Shortgrass Prairie (in a different Macrogroup) so fixing auto-key would be more fruitful.

- Chihuahuan Loamy Plains Desert Grassland
- Chihuahuan Gypsophilous Grassland and Steppe
- Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
- Chihuahuan Sandy Plains Semi-Desert Grassland
- Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

Table 11. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M086 Chihuahuan Desert Scrub	3	49	61%	67%
M087 Apacherian-Chihuahuan Semi-Desert Grassland & Steppe	5	41	12%	41%
M130 Tamaulipan Scrub & Grassland	2	53	13%	13%
M093 Great Basin Saltbrush Scrub	1	15	60%	60%
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe	1	1	0%	0%
M170 Great Basin & Intermountain Dwarf Sage Shrubland & Steppe	1	7	100%	100%
M171 Great Basin & Intermountain Dry Shrubland & Grassland	1	27	4%	4%
M008 Southern Mixed Deciduous-Evergreen Broadleaf Forest	1	3	67%	67%
M157 Loblolly & Shortleaf Pine - Oak Forest & Woodland	1	5	0%	0%
M010 Madrean Warm Lowland Evergreen Woodland	2	51	2%	6%
M015 Comanchian Forest & Woodland	4	108	65%	86%
M158 Southern Plains Scrub Woodland & Shrubland	1	12	17%	17%
M012 Central Oak-Hardwood & Pine Forest	1	50	74%	74%
M016 Southern Hardwood & Pine Forest	2	51	71%	82%
M017 Northern Rocky Mountain Lower Montane & Foothill Forest	2	5	0%	0%
M020 Rocky Mountain Subalpine & High Montane Conifer Forest	4	24	0%	0%
M022 Southern Rocky Mountain Lower Montane Forest	4	62	69%	82%
M027 Rocky Mountain Two-needle Pinyon - Juniper Woodland	2	72	64%	96%

M154 Edwards Plateau Riparian Shrubland & Woodland	1	25	8%	48%
M116 Great Plains Cliff, Scree & Rock Vegetation	1	4	0%	0%
M049 Southern Rocky Mountain Montane Grassland & Shrubland	3	35	37%	37%
M051 Great Plains Mixedgrass Prairie & Shrubland	3	79	48%	58%
M052 Great Plains Sand Grassland & Shrubland	2	47	89%	91%
M053 Great Plains Shortgrass Prairie & Shrubland	2	100	47%	48%
M054 Great Plains Tallgrass Prairie, Savanna & Shrubland	1	3	100%	100%
M082 Cool Semi-Desert Alkali-Saline Wetland	1	1	100%	100%

GeoArea 7E

US-NVC Groups

Within this GeoArea, some 138 terrestrial ecological system types could occur. Of these, 12 have a practical 1:1 relationship with NVC Group concepts, and the remaining 121 system concepts (except for 5 with no NVC Group assignment) nest cleanly within 49 NVC Group concepts (1: many group : system relationship). There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the auto-key would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing auto-keys. Within this GeoArea, no ecological system types have a more complex relationship with NVC Group concepts.

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table (Results Workbook), and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 1).

There are 11 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 1 suggest rolling up to Macrogroup would yield improved results, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example, four macrogroups together encompass 23 ecological systems and a large proportion of the natural upland forests acreage of GeoArea 7E. These are:

- M014 Northern Mesic Hardwood & Conifer Forest (seven systems)
- M012 Central Oak-Hardwood & Pine Forest (seven systems)
- M159 Northern & Eastern Pine – Oak Forest, Woodland & Barren (five systems)
- M016 South-Central Oak – Hardwood & Pine Forest (four systems)

Table 12. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M012 Central Oak-Hardwood & Pine Forest	7	336	41%	79%
M014 Northern Mesic Hardwood & Conifer Forest	7	317	52%	77%
M016 South-Central Oak - Hardwood & Pine Forest	4	129	59%	81%
M153 Central Mesophytic Hardwood Forest	4	202	24%	25%
M159 Northern & Eastern Pine - Oak Forest, Woodland & Barrens	5	156	40%	42%
M030 Northern & Central Swamp Forest	1	15	27%	40%
M033 Southern Coastal Plain Basin Swamp	1	7	43%	43%
M122 Appalachian & Laurentian Rocky Scrub & Meadow	2	56	32%	48%
M124 Northern & Central Alvar & Glade	2	10	0%	0%
M127 Eastern North American Sub-Boreal Shrubland & Grassland	1	1	0%	0%
M057 Eastern North American Coastal Grassland & Shrubland	1	4	100%	100%

The project contingency table for this GeoArea arranged ecological system types according to the US-NVC Macrogroup that would encompass their existing vegetation components. This facilitates rapid analysis to evaluate the potential effect of using the auto-key for Macrogroups; i.e., there may be disagreements between expert and auto-keys at the ecological systems level that would be resolved if the intention was to roll-up labeled classes to broader Macrogroup classes.

Some examples of how generalizing up from the from ecological system to Macrogroup level would improve the agreement between the auto-key and expert assignments include:

- The Central Oak-Hardwood and Pine Forest Macrogroup is comprised of upland hardwood and pine forests of the Allegheny, Appalachian, and Southern Ridge and Valley / Cumberland Plateau ecoregions. Because the need to understand the biogeographic context for the plots would be reduced, rolling up to Macrogroup improves the matches between autokey and expert from 41 to 79%
- The Northern Mesic Hardwood and Conifer Forest Macrogroup is comprised of hemlock-northern hardwood forests and spruce-fir forests of the Laurentian and Acadian regions, as well as the central and southern Appalachians. Rolling up the macrogroup would increase agreement between experts and the existing sequence tables by 25% , going from 52-77% agreement.
- Combining four systems represented in the South-Central Oak-Hardwood & Pine Forest Macrogroup increases agreement from 59-81%. Scaling up to the macrogroup level would combine four relatively distinct ecological systems: Southeastern Interior Longleaf Pine Woodland, Southern Appalachian Low-Elevation Pine Forest, Southern Piedmont Dry Oak-(Pine) Forest, and Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest. In this GeoArea, only 5 plots were available for the Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest and

24 plots were included for Southeastern Interior Longleaf Pine Woodland. Those two systems had relatively high agreement level with 4 of the 5 coastal plain forest plots and 21 of the 24 longleaf plots already in agreement. These favorable results would be obscured by rolling up to the Macrogroup level. However, an increase in agreement would be made by combining two systems within the macrogroup, the Southern Appalachian Low-Elevation Pine Forest and the Southern Piedmont Dry Oak – (Pine) Forest. There were 27 plots that experts had attributed to the Southern Piedmont Dry Oak – (Pine) Forest that had been labeled by the auto-key as the Southern Appalachian Low-Elevation Pine Forest.

- Little is gained by moving to the macrogroup level for the Central Mesophytic Hardwood Forest Macrogroup, comprised of mesic forests of the southern piedmont, southern and central Appalachians, and south-central interior. Most of the disagreement in labeling those systems was among macrogroups, and lay in the difficulty in distinguishing the mesic types from the dry upland oak types throughout the GeoArea.

It is important to recognize that an important source of disagreement in many of the systems was the result of a plot being assigned to “can’t assign” or other. It is unclear how many of those plots could be easily assigned at the macrogroup level, when for many of the plots those calls were made because of a lack of information relative to species composition, or when the plot data and the photo indicated a change had occurred. Ruderal types will continue to be a challenge, and at the macrogroup level the expansion of the species list to accommodate all member systems may in fact make it more difficult to confidently label a plot.

GeoArea 7W

US-NVC Groups

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. However, within this GeoArea, no ecological system types have a more complex relationship with NVC Group concepts.

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table, and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 1).

There are 12 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 1 suggest rolling up to Macrogroup would yield improved results, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example, rolling up plot attribution to the Central Oak-Hardwood & Pine Forest Macrogroup increases the percent of matches of auto-key versus expert reviewer assignments from 45% to 75%. That Macrogroup includes nearly all the common, oak-dominated dry and dry-mesic forests from the western Appalachians west through the glaciated Midwest and unglaciated Interior Low Plateau to the oak woodlands scattered in the eastern Great Plains. Tightening up the geographic range parameters and characteristic relative abundances of the dominant oaks would yield significant improvements in the attribution correspondence while maintaining the ecological detail available using Systems. There are five cases where rolling up results to the Macrogroup level gains little

in terms of increasing the percentage of matches between auto-key and expert attributions but still results in a loss of ecological detail. Many of the disagreements between auto-keyed and expert assigned attributions were due to the expert not being able to assign sites to a natural System due to a lack of sufficient data or because the site was highly disturbed and fell within a ruderal or cultural type. Adding some kind of check on the data to reduce these occurrences would increase the agreement in attribution.

Table 13. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M008 Southern Mixed Deciduous-Evergreen Broadleaf Forest	1	47	13%	13%
M012 Central Oak-Hardwood & Pine Forest	6	261	45%	75%
M014 Acer saccharum - Betula alleghaniensis - Pinus strobus - Tsuga canadensis Forest	5	199	25%	38%
M016 Southern Hardwood & Pine Forest	8	259	52%	79%
M153 Acer (barbatum, saccharum) - Tilia americana - Fagus grandifolia - (Liriodendron tulipifera) Forest	5	209	40%	49%
M159 Northern & Eastern Pine - Oak Forest & Barrens	2	99	41%	63%
M030 Northern & Central Swamp Forest	5	102	62%	65%
M033 Southern Coastal Plain Basin Swamp	2	12	25%	50%
M037 Eastern & Central North American Boreal Conifer & Hardwood Forest	3	114	18%	21%
M300 North American Boreal Flooded Forest	1	50	0%	0%
M054 Great Plains Tallgrass Prairie, Savanna & Shrubland	1	1	0%	0%
M124 Northern & Central Alvar & Glade	4	50	0%	0%

GeoArea 8

US-NVC Groups

Within this GeoArea, some 138 terrestrial ecological system types could occur. Of these 9 have a practical 1:1 relationship with NVC Group concepts, and 121 nest cleanly within 44 NVC Group concepts (1: many group : system relationship), for a total of 130 or 94% of ecological system concepts with a clean relationship to an NVC Group. There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the autokey would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing autokeys. Within this GeoArea, just 3 (2%) of ecological system types have a more complex relationship with NVC Group concepts. Here we provide additional commentary on the implications for autokey adjustment brought by these types.

Table 14. Ecological Systems of GeoArea 8 that have complex relationships with NVC Groups. Interrelated Systems and Groups are shown in the heavy-outline boxes. The number of NVC Groups each system is related to is shown in the Groups column, and the number of Ecological Systems to which each NVC Group related is shown in the Systems column.

Ecological System	NVC Group	Groups	Systems
North Pacific Shrub Swamp	G256 North Pacific Maritime Hardwood-Conifer Rich Swamp	3	2
North Pacific Shrub Swamp	G610 North Pacific Maritime Poor Swamp & Bog Forest	3	1
North Pacific Shrub Swamp	G322 Vancouverian Wet Shrubland	3	2
Alaskan Pacific Maritime Poorly Drained Conifer Woodland	G256 North Pacific Maritime Hardwood-Conifer Rich Swamp	1	2
Alaskan Pacific Maritime Subalpine Copperbush Shrubland	G322 Vancouverian Wet Shrubland	1	2

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE autokeys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and autokeys found at the ecological systems level. To evaluate the potential effect of using the autokey for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-autokey contingency table, and also compared the percent of expert-autokey matches at the system level versus the Macrogroup level (Table 1).

There are 21 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. There may be disagreements between expert and autokeys at the ecological systems level that would be resolved if the intention was to roll-up labeled classes to broader Macrogroup classes. The following types listed below are those for which this could be the case within this GeoArea, although for some of these the increase in percent of matches is small.

Tsuga heterophylla - *Picea sitchensis* - *Sequoia sempervirens* - *Acer macrophyllum* Forest Macrogroup
 Vancouverian Flooded & Swamp Forest Macrogroup
 Western North American Boreal Conifer & Hardwood Forest Macrogroup
 Vancouverian Alpine Scrub, Forb Meadow & Grassland Macrogroup
 Western Boreal Alpine Macrogroup
 North American Arctic Tundra & Subarctic Alpine Macrogroup
 Arctic Tundra Wet Meadow & Marsh Macrogroup
 Northern Vancouverian Lowland & Montane Grassland & Shrubland Macrogroup
 North American Boreal Shrubland & Grassland Macrogroup
 North American Boreal Bog & Fen Macrogroup

Drosera rotundifolia - *Comarum palustre* - Brown mosses - *Sphagnum* spp. North Pacific Bog & Fen Macrogroup
 Western North American Boreal Shrubland, Wet Meadow & Marsh Macrogroup
 North American Pacific Coastal Salt Marsh Macrogroup

Table 15. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M173 North American Arctic Tundra & Subarctic Alpine Macrogroup	14	272	22%	63%
M174 Arctic Tundra Wet Meadow & Marsh Macrogroup	10	200	44%	79%
M156 Western North American Boreal Conifer & Hardwood Forest Macrogroup	8	160	41%	67%
M024 <i>Tsuga heterophylla</i> - <i>Picea sitchensis</i> - <i>Sequoia sempervirens</i> - <i>Acer macrophyllum</i> Forest Macrogroup	5	100	67%	94%
M062 North American Boreal Bog & Fen Macrogroup	4	81	10%	12%
M172 Northern Vancouverian Lowland & Montane Grassland & Shrubland Macrogroup	4	80	46%	73%
M055 North American Boreal Shrubland & Grassland Macrogroup	3	61	38%	72%
M081 North American Pacific Coastal Salt Marsh Macrogroup	3	60	48%	80%
M404 Western Boreal Alpine Macrogroup	3	60	45%	55%
M063 <i>Drosera rotundifolia</i> - <i>Comarum palustre</i> - Brown mosses - <i>Sphagnum</i> spp. North Pacific Bog & Fen Macrogroup	3	60	10%	12%
M101 Vancouverian Alpine Scrub, Forb Meadow & Grassland Macrogroup	2	40	18%	40%
M035 Vancouverian Flooded & Swamp Forest Macrogroup	2	40	5%	8%
M300 North American Boreal Flooded Forest Macrogroup	2	40	0%	0%
M072 Western North American Boreal Shrubland, Wet Meadow & Marsh Macrogroup	2	40	0%	3%
M073 Western North American Temperate Lowland Wet Shrubland, Wet Meadow & Marsh Macrogroup	2	40	0%	0%
M109 <i>Nuphar polysepala</i> - <i>Azolla filiculoides</i> - <i>Elodea nuttallii</i> Western North American Freshwater Aquatic Macrogroup	1	20	85%	85%
M299 North American Boreal Swamp & Bog Forest Macrogroup	1	20	80%	80%

M025 Abies magnifica - Abies X shastensis - Tsuga mertensiana - Pinus contorta var. murrayana Forest Macrogroup	1	20	70%	70%
M120 Vancouverian Alpine Cliff, Scree & Rock Vegetation Macrogroup	1	20	25%	25%
M179 North American Subalpine & Subarctic Woodland Macrogroup	1	20	15%	15%
M175 Arctic & Boreal Cliff, Scree & Rock Vegetation [Placeholder] Macrogroup	1	20	15%	15%

GeoArea HI

US-NVC Groups

Within this GeoArea, some 32 terrestrial ecological system types could occur. Of these, 15 have a practical 1:1 relationship with NVC Group concepts, and the remaining 17 system concepts nest cleanly within 8 NVC Group concepts (1: many group : system relationship). There is some potential for slight differences among floristic elements among these NVC Groups relative to ecological systems. For example, one or more associations linked to a given terrestrial ecological system type may now be linked to a different NVC Group concept. There is some limited potential that the floristic information found within the auto-key would need to be revisited to account for this, but within this GeoArea, we believe that this instance is quite limited.

Where the relationship between ecological systems and NVC Groups is more complex, there is potential need for substantive changes to existing auto-keys. Within this GeoArea, no ecological system types have a more complex relationship with NVC Group concepts.

US-NVC Macrogroups

Ecological Systems can be fairly comfortably rolled up to broader US-NVC Macrogroups, which cover the existing-vegetation component of their related ecological systems. Using LANDFIRE auto-keys for US-NVC Macrogroups instead of ecological systems could potentially resolve disagreements between experts and auto-keys found at the ecological systems level. To evaluate the potential effect of using the auto-key for Macrogroups, we arranged the ecological system types by US-NVC Macrogroup in the expert-auto-key contingency table, and also compared the percent of expert auto-key matches at the system level versus the Macrogroup level (Table 1).

There are 7 US-NVC Macrogroups represented among natural mapped classes in this GeoArea. While the results in Table 1 suggest rolling up to Macrogroup would yield improved results, consideration must be given to the fact that many of these Macrogroups are in fact very broad concepts, and include ecologically diverse system types. For example, because of the confusion over lowland versus montane dry forests, using the macrogroups M210 Hawaiian Dry Forest combines Hawai'i Lowland Dry Forest and Hawai'i Montane-Subalpine Dry Forest and Woodland and significantly improves the percent of expert matches at MG level from 33% to 67%. This holds true for several other Macrogroups (Table 1).

However, combining Hawai'i Dry Cliff and Hawai'i Dry-Site Lava Flow into M265 Hawaiian Cliff, Scree & Rock Vegetation or combining Hawai'i Dry Coastal Strand and Hawai'i Wet-Mesic Coastal Strand into M231 Hawaiian Scrub & Herb Coastal Vegetation does not improve the percent matching. On the other hand, combining Hawai'i Lowland Dry Grassland and Hawai'i Lowland Dry Shrubland into M217

Hawaiian Lowland Shrubland, Grassland & Savanna does significantly improve the percent matching (6% to 31%), but at a cost of grouping grassland with shrublands, which are likely useful to keep separate for mapping and management purposes.

Table 16. Comparison of auto-keyed results when plots keyed to systems are rolled up to Macrogroups, showing percent of matches at the system level compared to Macrogroup level

Macrogroup	# auto-keyed systems	# plots	% expert matches at system level	% expert matches at MG level
M210 Hawaiian Dry Forest	1	18	33%	67%
M187 Hawaiian Lowland Rainforest	3	77	10%	19%
M194 Hawaiian Montane & Cloud Forest	2	109	30%	49%
M265 Hawaiian Cliff, Scree & Rock Vegetation	2	7	57%	57%
M217 Hawaiian Lowland Shrubland, Grassland & Savanna	2	16	6%	31%
M231 Hawaiian Scrub & Herb Coastal Vegetation	1	17	47%	47%
M085 West Pacific Salt Marsh	1	4	0%	0%